I. MEASUREMENT OF SMALL CAPTURE CROSS SECTIONS FOR SLOW NEUTRONS

II. TOTAL CROSS SECTIONS FOR PHOTO-NEUTRONS

BY

CARL OLIVER MUEHLHAUSE

B.S., University of Virginia, 1940

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AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSICS IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF ILLINOIS, 1943

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I. MEASUREMENT OF SMALL CAPTURE CROSS SECTIONS FOR SLOW NEUTRONS

A. The method of measuring capture cross sections for slow neutrons which was developed by Coltman and Goldhaber* has been improved. The previous method was based on a comparison of the absorption of slow neutrons in a mixture of carbon and an element under investigation, with a carbon-boron mixture of equivalent absorption. Because of the small capture cross section of carbon ($\sigma_c < 10^{-26}cm^2$) this method can be used for the determination of fairly small capture cross sections if a suitable correction for the scattering of the material is taken into account. However, for capture cross sections $< 10^{-25}cm^2$ a small uncertainty in the scattering correction will lead to a large error in the value obtained for the capture cross section.

It was therefore desirable to make a scattering insensitive arrangement for the further investigation of very small capture cross sections, and this has been achieved by a modification of the previous arrangement. The method was then applied to a few elements of small capture cross section which turned out to be of the order of $10^{-26}cm^2$., i.e. of the same order as that of carbon.

A particularly interesting case investigated is Be whose capture cross section appears to be smaller than that of carbon. Because of its relatively small mass Be may play a role as an element which could replace hydrogen ($\sigma_c = .3 \times 10^{-24}cm^2$) as a slowing medium for neutrons.

B. The above method has a limitation in the fact that it assumes exactly equal angular dependence of scattering for different materials. Slight deviations which may be expected due to molecular interference effects would become serious for very small capture cross sections and therefore it is desirable to develop a method which is not sensitive to such small deviations.

A knowledge both of the diffusion length l for slow neu-

*J. W. Coltman, PH.D. Thesis, June 1941, University of Illinois.

trons and the scattering cross section of a material permits the computation of the capture cross section. Therefore, a method has been developed which allows the determination of l from the neutron density as a function of the distance from a neutron source. This method should be valid no matter how small the capture cross section is, the only practical limitation being that large quantities of the pure material are necessary. It was therefore not possible to apply the method to the most interesting case, Be; so to demonstrate it the experiment was performed on a pure Virginia coal.

The work indicated that this substance behaves like a "diluted" water as far as scattering and absorption is concerned and hence it might prove useful for experiments where it is desirable, (in order to avoid γ-rays or fast neutrons), to make the source-detector distance larger than is practicable in water or paraffin.

II. TOTAL CROSS SECTIONS FOR PHOTO-NEUTRONS

To determine the total cross section for fast neutrons of energy E it is necessary to be able to detect efficiently these neutrons with a detector which has a fairly small effective area. When E $<$ few hundred Kev it becomes increasingly difficult to use the hydrogen-filled ionization chamber as a detector. The energy of the recoil protons leads then to a pulse which is too close to the noise level of the amplifier. Several investigators have therefore used an arrangement in which the fast neutron beam is slowed down and then the slow neutrons detected. This has the disadvantage of giving rise to a fairly large detector size.

A new arrangement where the neutron beam is collimated by paraffin and cadmium has been devised which avoids this drawback. In this way the total cross sections for 220 Kev photo-neutrons (RdTh + D_2O) have been measured for the following elements:

H — 7.8×10^{-24} Be — 4.4×10^{-24} C — 3.7×10^{-24}

The hydrogen cross section is somewhat lower than the theoretically predicted value ($\sim 9 \times 10^{-24} cm^2$).

VITA

Carl Oliver Muehlhause was born in Baltimore, Maryland, in 1918. In this city he attended the public schools. In 1940 he was graduated with a Bachelor of Science degree from the University of Virginia. Since 1940 he has been at the University of Illinois as a fellow in physics. He received the Master of Science degree from the University of Illinois in 1941. He is a member of the American Physical Society, Sigma Xi, Phi Kappa Phi, and Phi Beta Kappa.

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